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### Reciprocating Piston Engine

The invention relates to a reciprocating piston machine comprising at least one working  
5 membrane and/or at least one auxiliary membrane made from an elastomeric material as  
well as an oscillating reciprocating drive engaging the membrane in a center zone, with a  
membrane zone, which deforms during the oscillating pumping movement, being  
provided between the central zone of the membrane, and a circumferential edge zone  
clamped in the reciprocating piston machine.

10 A reciprocating piston machine of the type mentioned at the outset has been known from  
DE 198 34 468 C1, which is embodied as a membrane pump. The membrane pump  
known from DE 198 34 468 C1 has a working membrane serving as a reciprocating  
piston made from an elastomeric material, which is clamped with its circumferential edge  
15 zone in the pump housing. An oscillating reciprocating drive engages the central zone of  
the working membrane, setting the membrane into a pumping movement. For this  
purpose, a stiff molded core is formed in the central zone of the working membrane,  
which is connected to a drive rod of the pump drive. A stiff support element is also  
connected to the molded core, which stiffens the working membrane and, during the  
20 pumping movements, limits the deforming membrane and flexing area to a comparatively  
small annular zone of the membrane.

In the working and/or auxiliary membrane of reciprocating piston machines of prior art  
two annular hinge zones develop regularly due to the pumping movement, one of which  
25 is located in the circumferential edge zone clamped in the pump housing and the other  
one at the interior circumference of the flexing area. In these hinge zones the working  
membranes and auxiliary membranes are subject to increased stress, which can lead to  
damages of the elastomer, used for the membrane, dysfunctions of the reciprocating  
piston machine, and increased noise production.

Therefore, the object is to particularly provide a reciprocating piston machine of the type mentioned at the outset with it being characterized by a working membrane and/or auxiliary membrane having a long life and a secure function.

- 5 The solution to this objective according to the invention comprises a reciprocating piston machine of the type mentioned at the outset, in particular in that the geometric adjustment of the working membrane and/or auxiliary membrane, different due to the stroke, to the mounting points provided in the central zone and at the circumferential edge zone results from two merging curves, which develop from a respective design of the membrane.

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Another alternative to meet the above-described objective provides for the cross-section of the working membrane and/or the auxiliary membrane to be sized in a deformable membrane zone, such that during the pumping movement approximately equal tension and/or elastic deformation develops in the deformable membrane zone.

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Further, an additional, also independently patentable solution to the above-described objective, provides for the working membrane and/or the auxiliary membrane to have at least two self-supporting annular zones in the deformable membrane zone, which merge in a reduction of the membrane cross-section, and that the cross-section of the membrane

20 in the annular zones are each enlarging beginning at the cross-sectional reduction.

- The working membrane and/or auxiliary membrane of the reciprocating piston machine according to the invention is sized in the deformable membrane zone, such that approximately equal tension and/or elastic deformation develop in the deformable
- 25 membrane zone during the pumping movement. Due to the fact that partial tension peaks in the upper surface membrane zone are avoided in the working membrane and/or auxiliary membrane, the geometrical deformation required by the stroking movement of the membrane and/or auxiliary membrane is not represented by two annular zones serving as hinges, but by two merging curves, with their merging point, depending on the
- 30 stroke, being located at a different position of the radius between the central zone and the circumferential zone clamped in the reciprocating piston machine. These curves develop

in that the force of the elastomer used for the membrane is selected for each position of the membrane such that during the deformation of the membrane the two merging curves develop by the stroke. In particular, this is achieved by the two cantilever-shaped annular zones, which are designed and sized such that in the normal position of the membranes the tension permitted for the annular zones develops evenly under the predetermined stress. The cantilever-shaped annular zones are characterized in that, beginning at the reduction of the cross-section, the cross-section of the membranes enlarges in each of the annular zones towards the outside (exterior annular zone) and/or towards the inside (interior annular zone.) Due to the fact that the working membrane and/or the auxiliary membrane of the reciprocating piston machine according to the invention is therefore embodied without any hinge area subject to any particular stress, the reciprocating piston machine is characterized by a long life and a low noise operation of its working membrane and/or auxiliary membrane.

Here, it is particularly advantageous for the cross-section of the membrane to at least partially enlarge linearly in the annular zones.

A particularly advantageous embodiment according to the invention provides for the reduction of the cross-section to be sized in the range from 0.6 to 0.8 in reference to the diameter of the deformable membrane zone.

Here, it is particularly advantageous for the reciprocating piston machine to be embodied as a membrane pump, with its fast-moving working membrane and/or auxiliary membrane regularly to be subjected to a particular stress.

The working membrane of such a membrane pump can be embodied as a molded membrane or as a flat membrane. While in the molded membrane a molded piece, connected via a drive rod of the stroke drive, is molded in the elastomer material of the membrane, in order to mold the membrane surface, facing the pump space, to the cross-section of the pump space such that the molded membrane completely fills the top dead center of the pump space, the flat membrane is clamped in its central zone between the

upper end of the drive rod and, on its membrane surface facing the pump space, a pressure disc.

Additional features of the invention are discernible from the following description of an exemplary embodiment of the invention in connection with the claims and the drawings. The individual features may each be embodied either in an embodiment according to the invention per se or combined with others.

In the drawings:

Fig. 1 a membrane pump in a partial longitudinal cross-section in an area of a pump head provided with a working membrane, and

Fig. 2 a detailed representation of the section, marked in dot-dash lines in Fig. 1 of the membrane pump according to Fig. 1.

In Fig. 1, a working membrane 1 serving as the stroke piston in a reciprocating piston machine, embodied as a membrane pump, is shown in a partial cross-section. The working membrane 1 comprises an elastomeric material, into which a molded piece 2 has been molded. While the molded piece 2 forming the central area 3 of the membrane 1 is connected to an oscillating drive rod 4 of a reciprocating drive, not shown here, the circumferential area 5 of the membrane 1 is clamped into the pump head 6 of the reciprocating piston machine.

Between the central area 3 of the membrane 1 and its circumferential area 5 clamped in the reciprocating piston machine, a membrane area or flexing area M is provided, which deforms during the oscillating pumping movements.

In order to avoid tension peaks in the upper surface zone of the deformable membrane area of the membrane 1, causing wear and sometimes also noise, the cross-section of the working membrane 1 is designed such that during the pumping movement almost

identical tension and/or elastic deformation develops in the surface area of the membrane 1, which can be deformed.

In the working membrane 1 shown here, the geometrical deformation required by the reciprocating movement is not represented by two hinged annular zones, as known from working membranes or auxiliary membranes of prior art, but by two merging curves with their merging point being located, depending on the position of the drive, at a different position of the radius between the membrane center 3 and the clamping point 5. These curves are developed by the strength of the elastomer used to produce the membrane 1 being selected such for each position of the membrane 1 that the two merging curves develop by the drive during the membrane deformation.

In order to reduce the tension developing during the flexing movement of the membrane and in order to be able to represent the geometric deformation of the membrane, required by the drive movement, not by two hinge points but by two merging curves, the working membrane 1 is provided with two cantilever-shaped annular areas 7, 8, which merge in the area of the exterior circumference of the deformable membrane area M. These cantilever-shaped annular areas 7, 8 are designed and sized such that in the normal position of the working membrane 1 the tension allowed for the annular area 7, 8 develops homogenously in every annular zone 7, 8 under the predetermined stress. The cantilever-shaped annular areas 7, 8 are characterized in that in these annular areas 7, 8 the cross-section of the membrane each enlarge from the cross-sectional reduction 9 outward (annular area 8) and/or inward (annular area 7). In Fig. 1 and in the detailed view according to Fig. 2 it is discernible that the cross-section of the working membrane 1 at least partially enlarges linearly in these annular areas 7, 8. Here, the cross-sectional thickness reduction 9 ranges from 0.6 to 0.8 in reference to the diameter of the deformable membrane area M, and forms the intersection of the extensions of the bottom sides of the annular areas defined by the annular areas 7, 8, positioned approximately at the narrowest point of the cross-sectional reduction 9.

Due to the fact that partial tension peaks in the upper surface zone of the deformable membrane area of the working membrane 1 provided herein are avoided, the membrane pump shown here is characterized in a long life and a low-noise operation of its working membrane 1.